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Edge-Enabled Tactical Systems

Carnegie Mellon Software Engineering Institute: Advanced Mobile Systems Team

Current Capabilities

Group Autonomy for Mobile Systems (GAMS)

Portable middleware, distributed algorithms and tools to support warfighter-directed groups of autonomous sensors and robotic systems. The focus for FY14 was on area coverage techniques that specialized in prioritized zones and mission-focused swarm formations such as shielding of important areas, people, or moving objects.

Information Superiority to the Edge (ISE)

Mobile application prototype that supports small edge units of soldiers or first responders by (1) sharing individual context information derived from sensors and manual input about events and activities; (2) improving accuracy and timeliness of task completion and reducing cognitive load by providing targeted information, group-coordination capabilities, and task guidance; and (3) capturing individual and group context for leveraging of resource (sensing, battery, processing, etc.) optimization models and activity-recognition algorithms. Recently added capabilities allow fine grained network and data optimization in Disconnected, Intermittent, Low-Bandwidth (DIL) environments by leveraging Delay Tolerant Networking (DTN) protocols and meta-data extensions for store-carry-forward data transmission and policy definition to shape context routing and forwarding in the network.

Edge Analytics

System that provides real-time situational awareness to warfighter and first responders units based on open source and social media data streams by (1) performing timeliness-accuracy tradeoffs to provide faster results in analyzing high velocity data streams; (2) providing macro trend analysis (sentiments, topics, named entities, location) on stream slices; (3) analyzing stream slices to incrementally identify network structure and metrics ; and (4) supporting interactive visualizations to allow operators to understand and digest high volumes of fast-moving data.

Cloudlet-Based Cyber-Foraging

Forward-deployed, virtual machine (VM) cloudlets that can be hosted on vehicles or other platforms and provide (1) infrastructure to offload computation, (2) forward data-staging for a mission (3) data filtering to remove unnecessary data from streams intended for dismounted warfighters; and (4) collection points for data heading for enterprise repositories.

FY14 Research Focus

Group Autonomy for Mobile Systems (GAMS): Develop middleware and algorithms to enable a single human operator to control a heterogeneous swarm of sensors, tailored to mission contexts

- Create algorithms for distributed prioritized and pheromone-based area coverage
- Create algorithms for swarm formation flying and target protection/tracking/swarming
- Support new VREP simulation platforms and Drone-RK quadcopter and Platypus boat real-world robotics platforms
- Create middleware for networked periodic applications with extensible platforms and distributed algorithms for C++, Java, Android, ARM, Intel and other architectures

Information Superiority to the Edge (ISE): Develop prototypes, architectures, and algorithms that apply advanced information processing and sharing capabilities; filter data to reduce cognitive load; and integrate advanced activity-recognition techniques to automatically determine the user's situation

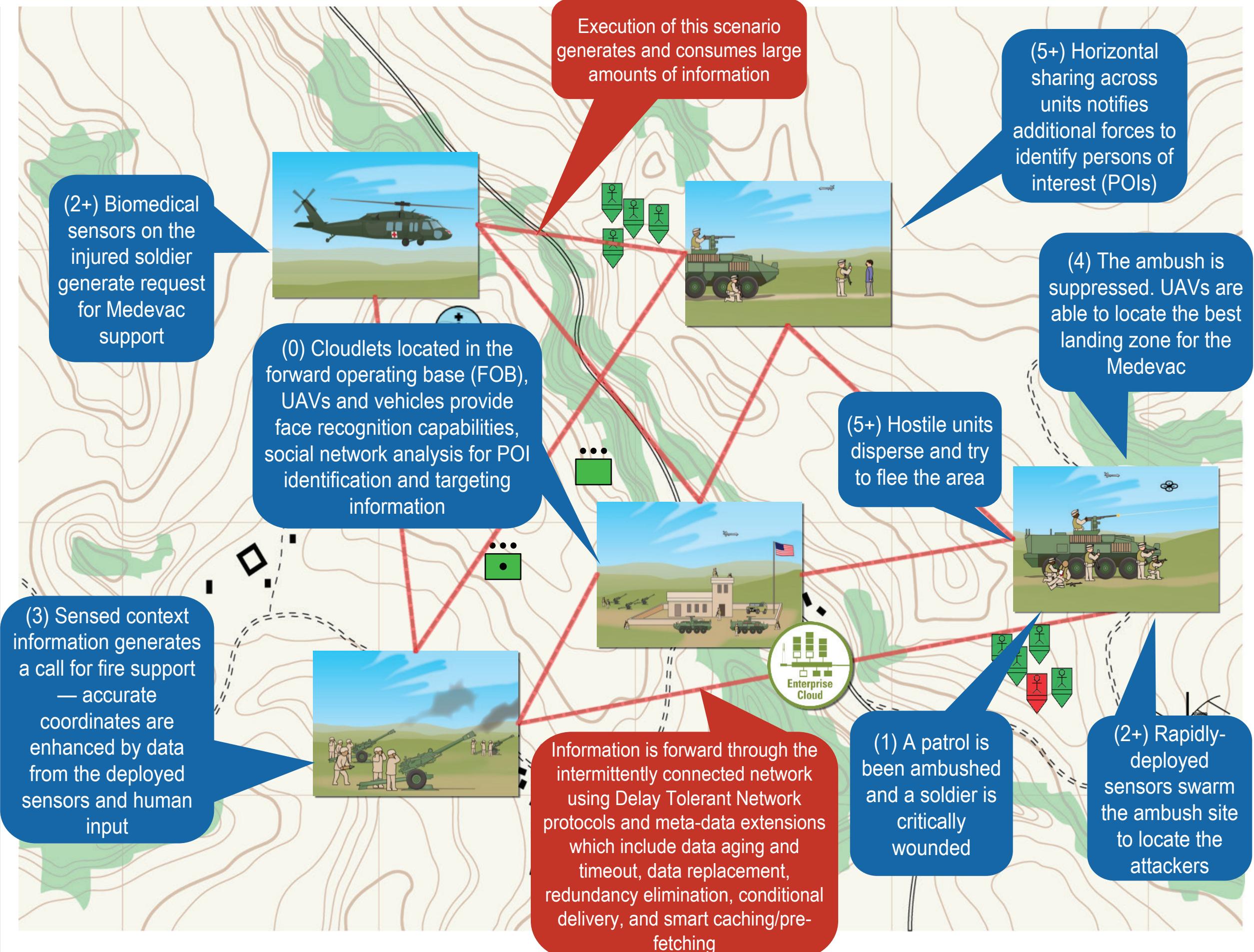
- Integrate with external software for better awareness at the edge
- Gather and use individual sensor data to perform activity recognition
- Demonstrate group context-awareness results in reduced cognitive load and improved task completion
- Demonstrate multiple link layer DTN routing/forwarding in DIL network environments

Edge Analytics: Enhance the situational awareness of edge users in near real-time (seconds to minutes) by analyzing social media streams and sensor streams to provide actionable intelligence, trends, and summaries

- Improve inference algorithms (semantics, multi-stream sensor)
- Develop adaptive algorithms and architecture for use in edge environments
- Increase usability by supporting end-user control

Cloudlet-Based Cyber-Foraging: Demonstrate that tactical cloudlets can increase the survivability of mobile software systems in the field

- Extend tactical cloudlet implementation by adding capabilities targeted at increasing mobile systems survivability, such as optimal cloudlet selection, cloudlet handoff (live migration), ease of management and deployment, and support for disconnected operations
- Validate new capabilities against a set of survivability metrics for mobile systems in edge environments



FY15 Research Focus

Establishing Trusted Identities in Disconnected Tactical Environments

We will develop trusted identity solutions that work within the constraints of DIL environments in which there is no consistent access to third-party online trusted authorities that validate the credentials of the requester or a certificate repository. Developed solutions will be validated and integrated in the tactical cloudlet implementation.

Assigning Credibility Scores to Social Media Streams in Real-Time

Trust in the credibility of information provided by social media channels is a key challenge. We will develop an algorithm that can assign a credibility score quickly (seconds) and provide a human-understandable chain of reasoning in the end user's vocabulary to evaluate the veracity of data.

Fusion of Social and Physical Sensor Data

This effort will improve trust in situational awareness by developing techniques to fuse data from social media with non-textual data and data from physical opportunistic sensors. We will develop algorithms that extract sensor metadata, other contextual data about the particular sensor, and where possible, analyze non-textual and sensor data to infer context to generate and assign new metadata.

Group Autonomy for Mobile Systems

GAMS is transitioning to the FY15 LENS ELASTIC and FY15 LINE DART projects. ELASTIC will focus on middleware and algorithms for distributed autonomous systems that dynamically respond to user needs, resources, and mission contexts. It will also develop complementary algorithms, called accents, which amplify a core algorithm to allow the autonomous agent to work on multiple missions simultaneously. DART focuses on the verification of distributed cyber-physical systems and will be using the GAMS middleware as a target platform.